COMPARISON OF TWO METHODS OF PRESENTATION FOR NONNEGATIVE RATIONAL NUMBERS AMONG PRESERVICE ELEMENTARY TEACHERS

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PREFACE

This study investigates computation in nonnegative rational numbers among preservice elementary teachers. The purpose is to determine if instruction in mathematics methods courses can increase achievment in nonnegative rational numbers using two different methods. They are a lecture/ demonstration method and a method based on Jerome Bruner's three modes of representation.

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CHAPTER I

THE RESEARCH PROBLEM

Introduction

Professional courses for teacher education in elementary mathematics give instruction in mathematics and on the use of materials and methods used in teaching and are grounded in the theories of Piaget, Bruner, Gagne, Dienes, and others. These courses are based on the assumption that preservice teachers possess the basic computational skills taught in elementary schools.

Overview of Problem

Mathematical competency is a basic element in the effective teaching of mathematics. When researching factors influencing the achievement of computational skills, Watson (1983) found a positive correlation between the mathematical skill levels of teachers and the mathematics achievement scores of their intermediate students. Results of a study by Hathaway (1983) showed that the number of semester hours of mathematics studied by the teacher made a significant difference in pupil performance. However, mathematical knowledge must be connected with teaching ability according to the studied opinion of The Educational Commission of the States (1983). The commission concludes that improvement of students' understanding of mathematics can only be accomplished by teachers who are well trained in mathematics <u>and</u> in the teaching of mathematics.

Better preparation in mathematics education at the college level is one way to provide better classroom teaching in mathematics (Isenberg & Altizer-Tuning, 1984). Critics have faulted institutions of teacher education for devoting too much time to educational "methods" courses and not enough time to subject matter (Berman & Friederwitzer, 1987). However, the subject matter courses needed by elementary teachers are not always available to them. In a nationwide study, Pitts (1974) found that there did not exist an identifiable pattern for meeting the mathematical needs of elementary majors in the undergraduate mathematics content courses in the universities he researched. This is in light of the fact that the Mathematical Association of American and the National Council of Teachers of Mathematics have published recommendations for many years. The Mathematical Association of American (Alder et al, 1983) recommends that for elementary teachers three courses should be required. The content of these courses should include the development of the whole and real number systems, geometry, measurement, probability and statistics, and basic computer concepts. The National Council of Teachers of Mathematics (Commission on the Education of Teachers of Mathematics, 1981) recommends that four courses should be completed by elementary and middle school teachers. These courses are:

1. a course on number systems through the rational numbers;

2. a course on informal geometry including mensuration, graphing, geometrical constructions, similarity, and congruence;

3. a course on topics in mathematics including the real number system, elementary probability and statistics, coordinate geometry and number theory; and

4. a course on the methods of teaching the mathemetics of the lower grades for primary teachers and the upper grades for intermediate and middle school teachers.

The assumption that preservice teachers possess basic computational skills is not always borne out in fact. Recently, the author tested elementary level computational skills of students in two intermediate mathematics methods courses at the university where she was teaching. Almost one-half of those tested showed deficient skills in nonnegative rational numbers. The mathematics methods course in which these students were enrolled has as a prerequisite any three hour mathematics content course carrying university credit. Dossey et al (1988) published an extensive report profiling the findings of the 1986 National Assessment Of Educational Progress. This report of

9, 12, and 17 year olds stated that the levels of proficiency exhibited by American students, particularly in the higher age groups, are likely to be inadequate for the demands of the times. Apparently, these deficiencies are not remedied by the time preservice elementary teachers complete their lower division coursework.

Purpose of the Study

The purpose of this study was to answer the question, "Can instruction in an elementary mathematics methods course improve computation skills of preservice teachers?" Specifically, this study compared two methods of instruction: a lecture/demonstration method that assumed computational competency and a theory based method designed to assure competency by including enactive, iconic, and symbolic components. The computational skills studied were nonnegative rational numbers.

The lecture/demonstration method consisted of teacher lectures from a selected mathematics methods textbook (Ashlock et al, 1983). Pattern Blocks, Cuisenaire Rods, and Base Ten Blocks were used for demonstration and short hands-on activity sessions. All three representations (enactive, iconic, symbolic) were not included for all topics covered. Computational competency was assumed, so no objectives for basic skills were given. The emphasis was on methods of teaching, and no specific instruction or review in basic skills were given.

The theory based model was developed from the works of Jerome Bruner. Computational competency was not assumed, but was a goal. The same mathematics methods textbook (Ashlock et al, 1983) was used as with the lecture/demonstration method. However, specific skills were identified and addressed. The study of each of these skill topics began with a stated objective, included enactive, iconic, and symbolic activities, and terminated with a computational evaluation.

Definition and Terms

The following terms and definitions were utilized in this study:

1. Mathematics Achievement: The attainment of mathematical knowledge or proficiency by an individual as evidenced by a score on a test designed to measure mathematical skills and concepts.

2. Mathematics Content Course: A course, taught by a mathematics department, emphasizing a selected area of mathematical study.

3. Computational Competence: Possession of sufficient knowledge, skill, and experience in the basic skills of addition, subtraction, multiplication, and division of whole numbers, fractions, decimals, and percents to score

at the 80th percentile on a mathematics achievement test at the eighth grade level.

4. Mathematics Methods Course: A course emphasizing the teaching of a selected area of the mathematics curriculum.

5. ICSP test: The Individualized Computational Skills Program standardized computational test published, by Houghton-Mifflin Company.

The Research Question

This research investigated the effects on computational skill in nonnegative rational numbers among preservice elementary teachers using two different methods of instruction. Preservice elementary teachers in two classes of intermediate level mathematics methods courses in the 1988 spring semester were the subjects for this study. Method I was the lecture/demonstration method. Method II was the theory based model containing objectives; enactive, iconic, and symbolic components; and evaluation of skills. The following questions were addressed:

(1) Does a mathematics methods course significantly improve the computational skills in nonnegative rational numbers of preservice elementary education teachers?

(2) If Method I is used in an elementary mathematics methods course, do computational skills significantly improve in nonnegative rational numbers?

(3) If Method II is used in an elementary mathematics methods course, do computational skills significantly improve in nonnegative rational numbers?

(4) Is there a significant difference in the improvement of skill levels of preservice elementary teachers in nonnegative rational numbers when comparing Method I to Method II?

Assumptions

The basic assumptions of this study were as follows:

(1) The students enrolled in the selected mathematics methods courses are typical of college students in such courses.

(2) There is no known bias in the selection by the students of one section over the other.

(3) The mix of achievement levels is approximately the same across groups.

Limitations

This study was subject to the following limitations:

(1) The investigation covered only selected computational skills.

(2) Time constraints limited the study. The treatment period was organized around the regular allotted time for these concepts in the mathematics methods course.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

The review of the literature will examine three areas. They are (1) studies relating to the mathematical proficiency of preservice elementary teachers, (2) the theoretical basis of this research, and (3) related studies of efforts to affect the mathematical abilities of preservice elementary teachers. A synthesis of the literature will present the rationale for a method of instruction that attempts to assure the computational competency of preservice elementary mathematics teachers. The chapter will close with the research hypotheses.

Mathematical Ability of Preservice Teachers

Feistritzer (1983) surveyed college-bound seniors in 1982. A comparison was made of the Scholastic Aptitude Test scores for students who selected from thirty-six possible career choices. Those planning to study education were forty-eight points lower on the mathematics section than all college-bound seniors and they ranked thirty-third. Only seniors intending to major in home economics, ethnic studies, or trade and vocational fields had lower mathematics scores.

Jo and Robert Barger (1984) conducted a study of 3831 Eastern Illinois University students who graduated in the years 1982-1983. They collected data from education and noneducation majors on American College Test scores, high school rank, and university grade point average. Their findings showed that teacher certification graduates performed as well or better than nonteaching certification graduates on grade point averages. However, teaching certification graduates generally were one or two points weaker than nonteaching graduates in academic potential for college work as measured by their composite American College Test scores and high school percentile ranks. Specifically, the average American College Test scores of elementary education majors was eighteen as compared with twenty-two for all nonteaching graduates.

Higdon (1975) specifically measured the mathematics achievement of preservice and inservice teachers. His study was based on random samples of 1,008 prospective and experienced elementary teachers in the state of Texas during the 1972 spring semester. To collect data, two questionnaires, an attitude test, and three arithmetic subtests of a standardized achievement test were administered. Analysis of the data revealed that eleven and twelve percent of both samples had not completed a single college level mathematics course, while only twenty-six percent of both samples had completed as many as three. Mathematics was selected as a specialization by only 4.6 percent of the prospective and 3.5 percent of the experienced teachers. Of the experienced teachers, over one-third reported that it had been between five and ten years since they had completed a college level mathematics course. He also compared the achievement of both samples to elementary students. When comparing the scores with eighth and ninth grade norms, they ranked in the 70th and 60th percentiles respectively. Higdon concluded that these results indicate that prospective and experienced elementary teachers do not possess the desired mathematical fundamentals that are expected of most junior high school students. These achievement results were significantly related to the number of high school and college math courses completed. Respondents who completed a greater number of math courses in high school and college attained higher scores on arithmetic achievement than those completing fewer courses.

This review was limited to studies conducted in the last fifteen years. The author felt earlier studies lacked relevance to current research.

Theoretical Basis

This research attempted to find whether instruction in mathematics methods courses for preservice elementary teachers can increase computational competency. Portions of the instruction was based on the theory of Jerome Bruner.

Among the wide scope of his investigations, psychologist Jerome Bruner has studied intellectual growth, instruction, and mathematical learning. His observations in the labortory have yielded theoretical conclusions on how man goes from experience to the achievement of insight, understanding, and competence (Bruner, 1973). From these conclusions he has developed a theory of instruction and intellectual growth.

Theory of Instruction

Bruner's (1968) theory of instruction has four major features. They are 1) predisposition toward learning, 2) structure of knowledge, 3) sequence of presentation, and 4) reinforcement.

Learning depends upon the exploration of alternatives. To implant a predisposition toward learning, instruction must facilitate and regulate these explorations. To activate the learning experience, some optimal level of uncertainty is a condition. Curiosity is a positive response to uncertainty and ambiguity. Exploration can be maintained if the learner feels free to take risks.

Therefore, instruction should minimize the consequences of wrong alternatives. Predispostion toward learning also requires direction. This can be provided by a sense of the goal of a task and feedback of results as alternatives are tested.

Optimal structure is that which is most readily grasped by the learner. To achieve this level, instruction should include the three modes of representation (action, images, and symbols). It should be economical by minimizing the information the learner needs to hold in mind and process to achieve comprehension. And, it should be powerful by generating new propositions through making connections from information that seems separate.

The sequence of instruction affects the difficulty of achievement of mastery. There is no unique sequence for all learners because of the presence of individual differences of the learners. The course of intellectual development moves from action through image to the symbolic representations. Therefore, an optimal sequence would progress in the same direction. It may be possible to by-pass the first two stages, but only at the risk that the learner may not possess the imagery to fall back on if symbolic transformations fail to achieve the goal.

Learning occurs in a cycle; first is the formulation of a testing prodedure or trial, then the operation of this prodedure or trial, and finally the comparison of the results of the test with some criteria. Reinforcement in the form of knowledge of results must come at a time and at a place in this cycle where the knowledge can be used for correction. It should come when the learner is comparing the results of his try-out with the criteria that he seeks to achieve.

Intellectual Growth

Bruner (1968) feels intellectual growth occurs when human beings translate experience into a model of the world. They do this by representation. A system of representation consists of the rules by which a learner conserves events that are encountered. Events are represented by the actions they require, by pictures, or in words or other symbols. These modes of representation are enactive, iconic, and symbolic (Bruner, 1973).

Enactive representation is knowing through action. Many things are known which have no imagery and no words. Examples are riding a bicycle and skiing. Trying to teach these skills through words or diagrams is ineffective. This mode of representation is governed by a schema which interfaces learning and execution.

Iconic representation depends upon visual or other sensory organization and upon the use of summarizing images. It is governed by perceptual organization. An image carried in the mind or on a page can provide a schema around which action can be organized. Through images the learner selectively records events that are experienced.

Symbolic representation features words, language, or other symbols. Symbols are arbitrary and remote. Yet, they are highly productive and generate rules for manipulating reality not possible through actions or images. Symbols permit condensation and compacting of information, which allows deeper and broader understanding .

Bruner's (1968) research has shown that intellectual development runs the course of these three systems of representation until the human being is able to command all three. Growth is not a series of stages, but a successive mastering of these three representations along with their partial translation into each other (Bruner, 1973).

Each of the three modes of representation - enactive, iconic, and symbolic - has its unique way of representing events. Each places a powerful impression on the mental life of human beings, and their interplay persists as one of the major features of adult intellectual life (Bruner, 1966).

Gains in Achievement

Several research studies showing an increase in the mathematical skills of preservice and inservice teachers have been completed. Four are reported here.

Improvement of basic skills was as byproduct in a study by Tishler (1980). This study attempted to relieve the math anxiety of preservice teachers by specifically teaching to their areas of weakness in mathematics. Twenty-six students enrolled in elementary methods courses participated in the study. In addition to the regular class sessions, the experimental group met for thirteen weeks in specially designed study sessions. The instruction systematically covered the areas of weakness of the students as assessed by a pretest. Although the purpose of the study was to determine the change in math anxiety, mathematics achievement was also measured. The experimental group was found to be significantly higher than the control group on mathematics achievement when comparisons were made between pretests and posttests.

Pluta (1980) studied the effects of two instructional treatments to the learning of mathematics concepts by preservice elementary teachers. Forty-two students were classified as concrete operational, transitional, or formal operational and then were randomly assigned to either a laboratory mode of instruction or a quasi-lecture mode of instruction. The laboratory mode of instruction incorporated active manipulation of physical objects and an inductive approach. The quasi-lecture mode of instruction presented the content in a deductive form. The results indicated that for the transitional and formal operational students, those receiving the laboratory mode of treatment scored significantly higher than those receiving the quasi-lecture mode of treatment on the tests used to measure achievement and retention. Neither instructional treatment was effective in promoting learning by students classified as concrete operational.

Kleinhaus (1976) also found that a laboratory approach and manipulatives significantly increased the mathematical knowledge base of college students. The laboratory approach was used with fifty-one preservice teachers in a mathematics content course. Forty activities making use of manipulative materials were used by students working in groups. Comparisons of initial and terminal scores on an achievement test showed growth to be significant.

Berman (1981) developed an inservice program for elementary teachers on the topic of metric measurement. It employed activities for teachers that paralleled those suggested for children. Each activity built upon previous activities, using manipulatives throughout. The teaching method, the manipulative materials, and the printed matter were all intended to serve as models for subsequent use by participating teachers in their classrooms. The teachers were required to use these lessons in their classrooms. Pretest and posttests for metric knowledge were given. All participants exhibited significant gain in metric knowledge.

Synthesis of the Literature

Studies of the mathematical proficiency of preservice teachers were reviewed. The results show that, overall, those choosing teaching were either below average on the achievement tests or had not achieved mastery. The scores on the mathematics subtest of the Scholastic Aptitude Test of college bound seniors choosing teaching were forty-eight points below the average of all surveyed. The American College Test scores of college students majoring in education were four points below nonteaching majors. And, an examination of achievement scores of randomly selected preservice and inservice teachers showed them to be below mastery.

Research studies showing increases in the mathematics achievement of college students entering teaching were reviewed. Additional time, use of manipulatives, laboratory methods, and hands on experiences were shown to improve mathematical achievement with college students, preservice teachers, and inservice teachers. The achievement gains were, however, either a by-product of another study in a mathematics methods course or they were made in a mathematics content course for preservice teachers. No studies were found that specifically attempted to raise mathematics proficiency in an elementary mathematics methods course.

The theory of intellectual growth of psychologist Jerome Bruner, although aimed at elementary children, applies to human beings of all ages. Bruner's research has found that humans grow cognitively in three ways - by action (enactive), by image (iconic), and by language or other symbols (symbolic). He concludes that instruction should proceed in the same direction and include each mode of representation.

The review of the literature discloses that it is likely mathematics proficiency of preservice elementary teachers in mathematics methods courses is not near mastery. The thesis of the research study reported here contends that mathematics proficiency can be improved in the mathematics methods course by the inclusion of a supplementary math skills unit based on Bruner's theory of instruction. For each skill, a predisposition for learning was implanted by the establishment of goals (objectives) and completion of exploratory tasks containing enactive, iconic, and symbolic components. Reinforcement came in the form of evaluations that gave corrective feedback.

From these disclosures and contentions the following hypotheses have been drawn.

Research Hypotheses

For the purpose of stating these hypotheses, the methods will be labeled. The lecture/demonstration method of teaching will be labeled M_1 and the theory based model containing objectives, evaluation, and enactive, iconic, and symbolic components will be labeled M_2.

The null hypotheses are as follows:

HO_1: There is no significant difference in the pretest and posttest scores on a test of computation in nonnegative rational numbers of preservice elementary teachers enrolled in two sections of a mathematics methods course.

HO_2: There is no significant difference in the pretest and posttest scores on a test of computation in nonnegative rational numbers of preservice elementary teachers enrolled in a mathematics methods course using M_1.

HO_3: There is no significant difference in the pretest and posttest scores on a test of computation in nonnegative rational numbers of preservice elementary teachers enrolled in a mathematics methods course using M_2.

HO_4: There is no significant difference in the gains between the pretest and posttest scores on a test of computation in nonnegative rational numbers of preservice elementary teachers enrolled in a mathematics methods course when comparing M_1 and M_2.

The null hypotheses were tested against the alternate hypotheses, which are:

$H1_1$: There is a significant gain between the pretest and posttest scores on a test of computation in nonnegative rational numbers of preservice elementary teachers enrolled in two mathematics methods courses.

$H1_2$: There is a significant gain between the pretest and posttest scores on a test of computation in nonnegative rational numbers of preservice elementary teachers enrolled in a mathematics methods course using M_1.

$H1_3$: There is a significant gain between the pretest and posttest scores on a test of computation in nonnegative rational numbers of preservice elementary teachers enrolled in a mathematics methods course using M_2.

$H1_4$: When comparing the gains between the pretest and posttest scores on a test of computation in nonnegative rational numbers of preservice elementary teachers enrolled in a mathematics methods course of M_1 and M_2, M_2 gains are significantly higher than M_1.

Each hypothesis was tested for all four scores -- fractions, decimals, percents, and the total score for all three subtests. All comparisons were _a priori_. Both orthogonal and non-orthogonal comparisons were made. Each hypothesis was tested at the .05 level of confidence.

CHAPTER III

METHOD AND PROCEDURE

Introduction

This was an experimental study investigating the computation in nonnegative rational numbers among preservice teachers in two sections of an intermediate grade mathematics methods course. One teacher provided instruction in both classes. As a result of previous computation tests administered to preservice teachers and conclusions drawn from the literature only the pretest and posttest scores for nonnegative rational numbers were used. Specifically, this study compared a lecture/demonstration method that assumed computational competence and a theory based method designed to assure competence by including enactive, iconic, and symbolic components.

The lecture/demonstration method (Method I) consisted of teacher lectures derived from a selected mathematics methods textbook (Ashlock et al, 1983). Fraction concepts were were demonstrated with Pattern Blocks and Cuisenaire Rods. Decimals and Percents concepts were demonstrated with Base Ten Blocks. Students also participated in short hands-on activity sessions with these manipulatives. All three representations (enactive, iconic, symbolic) were not included for all topics covered. Computational competence was assumed, so no objectives for basic skills were given. The emphasis was on methods of teaching. There was no specific instruction or review in basic skills.

The theory based model (Method II) was developed from the works of Jerome Bruner. Computational competency was not assumed, but was a goal. The same mathematics methods textbook (Ashlock et al, 1983) was used as with the lecture/demonstration method. However, specific skills in were identified and addressed. The study of each of these skill topics began with a stated objective, included enactive, iconic, and symbolic activities, and terminated with a computation evaluation.

Population and Sample

This research was conducted as a field study during the spring semester of 1988. The author had no control over the selection of subjects or the assignment of subjects to groups. The author did have control of the assignment of groups to treatments; a flip of a coin was used in making the assignment. Later analyses will reveal no statistically significant differences between the groups on pertinent measures. As in other studies of this nature, the population is hypothetical as determined by the available sample.

The majority of students in these classes were juniors and seniors who had been admitted to teacher education. The class using Method I consisted of 28 female students. One student was a graduate and one was a sophomore. All were elementary education majors. The class using Method II consisted of 28 students. Two were male and two were graduate students. Three students were not elementary education majors. One student from each class was eliminated because of incomplete test scores leaving a sample of 27 in each class.

Instrument

The students' computational scores in nonnegative rational numbers were derived from Computation Test C (Forms A and B) from the Individualized Computational Skills Program, published by Houghton Mifflin Company in 1980.

The Individualized Computational Skills Program (ICSP) was developed as a supplementary mathematics program to teach students basic computational skills in grades one through twelve. It consists of several components, including standardized computational tests, skills inventory, teaching model cards, practice pages, and records of progress. The program was originally designed and developed, with statistical evaluation, during a seven-year period. The tests were normed and validated using more than 90,000 students in both large urban schools and smaller elementary and secondary schools throughout the country. The tests serve two types of evaluation, grade equivalence and achievement growth.

Computation Test C (Forms A and B) was designed to test computation skills in grades seven through twelve consisting of sixty problems, there are twenty problems on the basic operations of whole numbers, ten problems on the basic operations of fractions, ten problems on the basic operations of decimals, ten problems on rates, ratios, and proportions, and ten problems on percents. Students had forty-five minutes to complete the test. All sections were administered, but only the sections on fractions, decimals, and percents were used for this resarch. The greatest possible subscores for each section were ten with a total of thirty.

Content validity of these tests was demonstrated by the aptitudes, skills, and knowledge required of the students for succssful test performance. Computation with the four basic operations of fractions, decimals, and percents was the basic premise of this study. Each of these skills was addressed with ten test items. Although this test was designed for students in grades seven through twelve, computation for college students is not significantly different.

Reliability of the Instrument

Test reliability was determined by the split half reliability method. A correlation r was calculated between student scores obtained on Computation Test C (forms A and B) on two random halves of each subtest and on the test as a whole. The random halves chosen were the odd items and the even items. The r estimated the reliability of half the test. From this, the reliability of the whole test was estimated using the Spearman-Brown Formula (Isaac & Michael, 1985):

$$r_n = \frac{n(r)}{1+(n-1)r}$$

This formula gives the reliability of a test n times as long. In this case, n was equal to 2.

The reliabilities were established on the pretest and posttest scores, and are summarized in Table 1.

TABLE 1

RELIABILITY OF THE TEST AND SUBTESTS

PRETEST	RELIABIITY	POSTTEST	RELIABILITY
FRACTIONS	.84	FRACTIONS	.82
DECIMALS	.70	DECIMALS	.50
PERCENTS	.90	PERCENTS	.85
TOTAL	.92	TOTAL	.89

Research Design

The research design was quasi-experimental. It involved an applied setting where it was impossible to randomize the assignment of students to groups or groups to sections. However, the sections were randomly assigned to methods. Subjects in both sections were given a pretest on computation of nonnegative rational numbers. All conditions were the same for both groups, except that instruction in one section utilized Method I and the instruction in the other section utilized Method II. The period of instruction was designed to include four and one-half two hour class sessions. At the end of the treatment time, both groups were tested on computation of nonnegative rational numbers. Differences between the pretest and posttest means were compared. One-way within groups analyses of variances and a one-way between groups analysis of covariance were used as the statistical tests to determine whether the differences were significant.

Materials and Tasks

An activity book entitled "A Teacher's Kit for Rational Numbers" was prepared by the author together with concrete manipulatives consisting of circular and square regions. Activities in the booklet were carried out by the students and addressed skills in the basic operations of fractions, decimals, and percents. These activities were based upon Bruner's theory of instruction as outlined in Chapter 2.

The fraction unit consisted of basic skills, addition, subtraction, multiplication, and division of fractions. Materials consisting of circular regions made into fractional parts were an integral part of the activities. The decimal unit consisted of basic skills, addition, subtraction, multiplication and division of decimals. Materials consisting of square regions and strips representing wholes, tenths, and hundredths were used. The percent unit consisted of the concepts of percent and operations with percents. Materials consisted of square regions divided into hundredths.

Objectives were set forth at the beginning of each unit. Activities progressed through the three levels of concrete, pictoral, and symbolic representation. Each unit culminated with a written evaluation. A copy of the materials is in Appendix A.

Procedures

The ICSP Computation Test C (Form A) was administered to both classes at the beginning of the semester. Students were told that they would be a part of an experimental study but no specific reference to the study was made and no feed-back of test results was given until after the posttests were administered.

Both sections were given instruction from the same textbook (Ashlock et al, 1983). The teaching of fractions, decimals, and percents was studied during four and one-half class periods.

For one section (Method I), the lecture/demonstration method was employed. The content of the textbook was emphasized in the lectures with demonstrations to consist of manipulatives and pictoral models taken from the illustrations given in the textbook. The topic of session one was "Developing Concepts of Rational Numbers". It included making a Venn Diagram of the real number system, definition of rational numbers, ordering rational numbers, equivalent fractions, ratio, renaming to higher and lower terms, the relationship of fractions, decimals, and percents. The second and third sessions were "Developing Algorithms for Addition, Subtraction, Multiplication and Division of Fractions". These sessions included both developmental and the most efficient algorithms for the four operations on fractional numbers. Suggestions for concerete and semi-concrete activities were given. Session four and session five (one hour) were "Developing Algorithms for Decimals and Percents." These sessions covered the relationship of fractions and decimals, properties and rules with decimals, models of decimal problems, meaning of percent, solving percent problems using fractions and decimals, and solving percent problems using the ratio and proportion method.

The students in the other section (Method II) used the same textbook (Ashlock et al, 1983) and covered the same material as those using Method I. In addition, they were given the activity book based on Bruner's theory of instruction entitled "Teacher's Kit for Rational Numbers" and the corresponding manipulatives. This took place prior to the beginning of the first class period of the experimental study. At this time the instructor assigned, as homework, the sections titled "Making Sets of Equivalent Fractions" and "Equal Fractions" in the activity book. Other sections were assigned as homework for the entirety of the experimental period. Each succeeding class period consisted of (1) review and discussion of activities completed as homework which had been assessed by the instructor (2) discussion and collection of assigned homework (3) lecture from the textbook and (4) assignment of homework from activity book.

Assignment two was "Addition and Subtraction of Fractions". Assignment three was "Multiplying and Dividing Fractions". Assignment four was "Making and Regrouping Decimals", "Adding and Subtracting Decimals", and "Multiplying and Dividing Decimals". Assignment five was "The Meaning of Percent" and "Solving Percent Problems".

After the four and one-half week study was completed, the ICSP Computation Test (form B) was given.

Experimental Design and Analysis of Data

Data in the form of raw scores were collected from the pre and posttest assessments. The sections on nonnegative rational numbers from the ICSP Computation Test C Form A were utilized for the pretest; Form B was used for the posttest. The pretest set the baseline for students' computational scores on nonnegative rational numbers. The posttest determined if mathematics methods courses have an effect on computational scores and if the treatments would lead to one group obtaining a significantly greater gain in computational scores.

This study investigated four questions related to the computational skill levels on nonnegative ratiional numbers of preservice teachers. To analyze the data, one-way within subjects analyses of variance and one-way between subjects analysis of covariancee were used. Cell sizes were equal. To diminish the effect of preexisting individual differences, statistical adjustments were made by designating the pretest as a covariate and analyzing the data with the one way analysis of covariance.

CHAPTER IV

RESULTS OF THE STUDY

The presentation and analysis of the data are divided into four major sections congruent to the four questions asked in this study. The questions were:

1. Will there be a significant difference in the pretest and posttest scores of computation of nonnegative rational numbers after an intermediate mathematics methods course?

2. Will there be a significant difference in pretest and posttest scores of computation of nonnegative rational numbers after an intermediate mathematics methods course using M_1?

3. Will there be a significant difference in pretest and posttest scores of computation of nonnegative rational numbers after an intermediate mathematics methods course using M_2?

4. will there be a significant difference in posttest scores of computation of nonnegative rational numbers when comparing M_1 and M_2 while holding the pretest scores constant?

Additional analyses will be made to assist in the translation of the data. These analyses will include a statistical listing, tests of association, and t-tests.

Summary of the Data

There were 56 students enrolled in the two sections of Teaching Mathematics at the Intermediate Level used in this study. Students who failed to take both the pretest and the posttest were eliminated from consideration in the statistical analysis. There were two students eliminated for this reason, one in each section, leaving 54 subjects for the experiment.

The data collected were from mathematics subscores on the ICSP Computation Test C, pretest scores and posttest scores. Each subject had four pretest and posttest scores, one each for fractions, decimals, and percents and the fourth for the total. A tabular summary of the data is contained in Appendix B.

Statistical Design

The analysis of the data for this experiment relied upon one-way within subjects analyses of variance for the first three questions and a one-way between subjects analysis of covariance for the fourth question. The computer program Systat (Wilkinson, 1987) was used for the analyses.

The basic limitations and assumptions of the analysis of variance are:

1. The design must be a fixed-effects model. This means that the levels of the independent variable have been arbitrarily chosen by the researcher and no generalizations are to be made beyond the levels that are studied.

2. The scores must be from a genuine interval scale.

3. The scores must be normally distributed in the population.

4. The variance in the treatment conditions or groups must be homogeneous.

> In most cases, violations of normality and homogeneity of variance do not severely effect the outcome of the analysis of variance. Although tests have been developed to determine non-normalcy and heterogeneity of variance, many are less robust than the analysis of variance and are more susceptible to distortion than the analysis of variance itself. (Linton and Gallo, 1975)

Eta Squared (η^2) was used as the measure of association for the ANOVAs. The computational formula used was (Jaccard, 1983):

$$\eta^2 = \frac{SS_x}{SS_{total}}$$

Eta squared represents the proportion of variance in the dependent variable that may be accounted for by the independent variable.

Analysis of covariance is an extension of analysis of variance in which the effect of the independent variables on the dependent variable is assessed after the effects of one or more covariates are partialled out. When subjects cannot be randomly assigned to treatments, the ANCOVA is used as a statistical matching procedure which removes prior differences between subjects in the different groups. (Tabachnick and Fidell, 1983).

The squared multiple R was used as the measure of association for the ANCOVAs. The multiple R is the measure of association between the dependent variables and the independent variables. The squared multiple R is the proportion of the dependent variable's variance shared with the independent variable. It takes on values between 0 and 1, with the former indicating no relationship with the independent variables and the latter indicating a perfect relationship. A low effect size is .10, a moderate effect size is .30 and a high effect size is .50. (Cohen & Cohen, 1983)

Statistical analyses of each treatment group were run. The descriptive statistics included listings of the number of cases, the minimum score, the maximum score, the mean and the standard deviation for each of the pre and post subtests and the total pretest and posttest. Table 2 shows these listings. When comparing the means of the two groups , the pretest means for the class using Method I were higher than the pretest means for the class using Method II. When comparing the posttest means for the class using Method I to those of the class using Method II, the posttest means for Method II were higher on the percent subtest.

t-tests were computed to determine if significant differences existed on the pretest scores of the two classes. Table 3 shows the results of these tests. Neither class was significantly higher on any pretest.

Testing the Hypotheses

To test each of the first three hypotheses stated in

TABLE 2

STATISTICS

	FRAC1	DEC1	PERC1	TOT1
	METHOD I			
N OF CASES	27	27	27	27
MINIMUM	3	4	0	14
MAXIMUM	10	10	10	30
MEAN	7.185	8.481	6.296	21.963
STANDARD DEV	2.058	1.602	3.244	5.33
	METHOD II			
N OF CASES	27	27	27	27
MINIMUM	1	4	1	9
MAXIMUM	10	10	10	29
MEAN	6.296	7.741	5.778	19.815
STANDARD DEV	2.509	1.992	2.607	5.623

	FRAC2	DEC2	PERC2	TOT2
	METHOD I			
N OF CASES	27	27	27	27
MINIMUM	3	7	1	16
MAXIMUM	10	10	10	29
MEAN	7.815	9.074	6.926	23.815
STANDARD DEV	1.861	0.997	2.868	4.507
	METHOD II			
N OF CASES	27	27	27	27
MINIMUM	1	4	2	8
MAXIMUM	10	10	10	30
MEAN	7.111	8.481	7.741	23.333
STANDARD DEV	2.722	1.762	2.459	5.824

TABLE 3

INDEPENDENT *t*-TESTS PRETEST
SCORES OF TWO GROUPS

SOURCE	t	P
FRATIONS	1.424	.161
DECIMALS	1.506	.138
PERCENTS	.647	.520
TOTAL	1.440	.156

Chapter I, four one-way within subjects analyses of variance were conducted. The fourth hypothesis was tested using the analysis of covariance. Within each hypothesis, four analyses were made, one for each of the three subparts of the test and one for the total.

Effect of Mathematics Methods Courses on Test Scores

To determine if taking a mathematics methods course increases computational skills in nonnegative rational numbers among preservice teachers, four one-way within subjects ANOVA F-tests were computed using data gathered from the pretests and posttests of all students completing both the pretest and posttest in both classes. Cell sizes were equal, so no adjustments were necessary.

The data from Tables 4-7 indicate that there is a significant gain at the .05 level of confidence between the pretest scores and posttest scores on all subtests.

The P values indicating the significance of the difference betwen the means for the pretest and posttest scores for the analyses were .029, .001, .000, and .000 with 1 and 53 degrees of freedom. Thus, there is sufficient evidence to reject the null hypotheses. The eta squared computations of the four analyses were .25, .17, .16, and .08, respectively. The strength of association shows that for the fraction, decimal, percent, and total posttest

TABLE 4

ONE WAY WITHIN SUBJECTS ANOVA
COMBINED - FRACTIONS

SOURCE	SS	DF	MS	F	P
TESTS	14.083	1	14.083	5.063	0.029*
TESTS X SUBJECTS	147.417	43	2.781		

TABLE 5

ONE WAY WITHIN SUBJECTS ANOVA
COMBINED - DECIMALS

SOURCE	SS	DF	MS	F	P
TESTS	12.000	1	12.000	12.720	0.001*
TESTS X SUBJECTS	50.000	53	0.943		

TABLE 6

ONE WAY WITHIN SUBJECTS ANOVA
COMBINED - PERCENTS

SOURCE	SS	DF	MS	F	P
TESTS	45.370	1	45.370	16.742	0.000*
TESTS X SUBJECTS	143.630	53	2.710		

TABLE 7

ONE WAY WITHIN SUBJECTS ANOVA
COMBINED - TOTAL

SOURCE	SS	DF	MS	F	P
TESTS	194.676	1	194.676	39.258	0.000*
TESTS X SUBJECTS	262.824	53	4.95		

* SIGNIFICANT AT THE .05 LEVEL

scores, 25%, 17%, 16%, and 8% of the portion of variance in the change in scores can be accounted for by attending a mathematics methods course. The effect sizes were moderate for fractions and low for decimals, percents, and total as defined by Cohen and Cohen (1983) in a previous section.

Effect of Method I on Test Scores

To determine if a mathematics methods course using Method I as described in Chapter 2 increases computational skills in nonnegative rational numbers among preservice teachers, four one-way within subjects ANOVA F-tests were computed using data gathered from the pretests and posttests of all students completing both the pretest and posttest in both classes. Cell sizes were equal, so no adjustments were necessary.

The data from Tables 8-11 indicate that there was a significant gain at the .05 level of confidence between the pretest scores and posttest scores on the decimal problems and on the total problems of the students in the mathematics methods courses using Method I.

There was not a significant difference at the .05 level of confidence between the pretest scores and posttest scores on the fraction problems or percent problems of the students in the mathematics methods course using Method I.

These findings show that those students who were in the class using Method I, the lecture-demonstration method, made

TABLE 8

ONE WAY WITHIN SUBJECTS ANOVA
METHOD I - FRACTIONS

SOURCE	SS	DF	MS	F	P
TESTS	5.352	1	5.352	2.276	0.143
TESTS X SUBJECTS	61.148	26	2.352		

TABLE 9

ONE WAY WITHIN SUBJECTS ANOVA
METHOD I - DECIMALS

SOURCE	SS	DF	MS	F	P
TESTS	4.741	1	4.741	6.084	0.021*
TESTS X SUBJECTS	20.259	26	0.779		

TABLE 10

ONE WAY WITHIN SUBJECTS ANOVA
METHOD I - PERCENTS

SOURCE	SS	DF	MS	F	P
TESTS	5.352	1	5.352	2.951	0.098
TESTS X SUBJECTS	47.148	26	1.9813		

TABLE 11

ONE WAY WITHIN SUBJECTS ANOVA
METHOD I - TOTAL

SOURCE	SS	DF	MS	F	P
TESTS	46.296	1	46.296	12.447	0.002*
TESTS X SUBJECTS	96.704	26	3.719		

* SIGNIFICANT AT THE .05 LEVEL

significant improvement in the area of decimal computation and on the total score. They did not make significant gains on the fraction or percent computation scores.

The P values indicating the significance of the difference between the means for the pretest and post scores for the analyses were .143, .021, .098, and .002 respectively with 1 and 26 degrees of freedom. Since the decimal problems and total problems were significant at the .05 level these null hypotheses can be rejected. The eta squares of the two analyses were .21 and .07, respectively. Decimals show a moderate effect size and total shows a low effect size.

Effect of Method II on Test Scores

To determine if taking a mathematics methods course using Method II increases computational skills in nonnegative rational numbers---four one-way within subjects ANOVA F-tests were computed using data gathered from the pretests and posttests of all students completing both the pretest and posttest in both classes. Cell sizes were equal, so no adjustments were necessary.

The data from Tables 12-15 indicate that there were significant gains at the .05 level of confidence between the pretest scores and posttest scores on the decimal problems, percent problems and total problems of the students in a mathematics methods course using Method II.

TABLE 12

ONE WAY WITHIN SUBJECTS ANOVA
METHOD II - FRACTIONS

SOURCE	SS	DF	MS	F	P
TESTS	8.963	1	8.963	2.709	0.112
TESTS X SUBJECTS	86.037	26	3.309		

TABLE 13

ONE WAY WITHIN SUBJECTS ANOVA
METHOD II - DECIMALS

SOURCE	SS	DF	MS	F	P
TESTS	7.407	1	7.407	6.508	0.017*
TESTS X SUBJECTS	29.593	26	1.138		

TABLE 14

ONE WAY WITHIN SUBJECTS ANOVA
METHOD II - PERCENTS

SOURCE	SS	DF	MS	F	P
TESTS	52.019	1	52.019	16.009	0.000*
TESTS X SUBJECTS	84.481	26	3.249		

TABLE 15

ONE WAY WITHIN SUBJECTS ANOVA
METHOD II - TOTAL

SOURCE	SS	DF	MS	F	P
TESTS	167.130	1	167.130	29.486	0.000*
TESTS X SUBJECTS	147.370	26	5.668		

* SIGNIFICANT AT THE .05 LEVEL

There was not a significant difference at the .05 level of confidence between the pretest scores and posttest scores on the fraction problems of the students in a mathematics methods course using Method II.

The P values indicating the significance of the difference between the means for the pretest and posttest scores for the analyses were .112, .017, .000, and .000 with 1 and 26 degrees of freedom. The decimal, percent and total scores were significant at the .05 level, therefore the null hypotheses can be rejected. The eta squares were .15, .22 and .07, respectively. Decimals and total showed a small effect sizes, while percents showed a moderate effect size.

Comparison of Teaching Method on Test Scores

To determine if teaching technique in a mathematics methods course increases computational skills in nonnegative rational numbers---four one-way between subjects analysis of covariance F-tests were computed using data gathered from the pretests and posttests of students completing both the pretest and posttest in two classes, one using Method I and one using Method II. The covariate was the pretest. Before analyzing the data with the analysis of covariance model, the interaction between the covariate and the treatment was tested to assure that it was not significant. The assumption of no interaction is called the "homogeneity of slopes" assumption. This means that the slope of the regression line of the dependent variable onto the covariate should be the same in all cells of the design. It is tested with a preliminary model with the interaction between treatment and covariate in the model. (Wilkinson, 1987). Cell sizes were equal, so no adjustments were necessary.

The data from Tables 16, 18, 20, and 22 indicate that there is no significant interaction between the treatment and the covariate for any of the four different analyses. The P value for the interactions were .419, .214, .188, and .373.

The data from Tables 17, 19, 21, and 23 indicate that the there were no significant differences at the .05 level of confidence between the pretest scores and posttest scores on the fraction problems, decimal problems, or total problems of the two groups of students. There was a significant difference at the .05 level of confidence between the pretest scores and posttest scores on the percent problems.

The P values indicating the significance of the differences between the means for the pretest and posttest scores for the analyses were .631, .497, .040, and 131 with 1 and 51 degrees of freedom. Thus, the hypotheses as they apply to the fraction, decimal and total subscores cannot be rejected. However, the hypothesis as it applies to the

TABLE 16

ANALYSIS OF INTERACTION BETWEEN
TREATMENT (CLASS) AND
COVARIATE (FRAC1)

DEP VAR: FRAC2 N: 54 MULTIPLE R: .500 MULTIPLE R2: .250

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CLASS	3.711	1	3.711	0.855	0.360
FRAC1	55.282	1	55.282	12.731	0.001
CLASS* FRAC1	2.882	1	2.882	0.664	0.419
ERROR	217.124	50	4.342		

TABLE 17

ANALYSIS OF COVARIANCE TABLE-FRACTIONS
COMPARING METHOD I WITH METHOD II

DEP VAR: FRAC2 N: 54 MULTIPLE R: .490 MULTIPLE R2: .240

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CLASS	1.005	1	1.005	0.233	0.631
FRAC1	62.735	1	62.735	14.543	0.000
ERROR	220.006	51	4.314		

TABLE 18

ANALYSIS OF INTERACTION BETWEEN
TREATMENT (CLASS) AND
COVARIATE (DEC1)

DEP VAR: DEC2 N: 54 MULTIPLE R: .687 MULTIPLE R2: .472

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CLASS	2.223	1	2.223	1.893	0.175
DEC1	40.089	1	40.089	34.127	0.000
CLASS* DEC1	1.862	1	1.862	1.585	0.214
ERROR	58.735	50	1.175		

TABLE 19

ANALYSIS OF COVARIANCE TABLE-DECIMALS
COMPARING METHOD I WITH METHOD II

DEP VAR: DEC2 N: 54 MULTIPLE R: .675 MULTIPLE R2: .456

ANALYSIS OF VARIANCE

SOURCE P	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CLASS	0.555	1	0.555	0.467	0.497
DEC1	45.996	1	45.996	38.711	0.000
ERROR	60.597	51	1.188		

TABLE 20

ANALYSIS OF INTERACTION BETWCEEN
TREATMENT (CLASS) AND
COVARIATE (PERC1)

DEP VAR: PERC2 N: 54 MULTIPLE R: .705 MULTIPLE R2: .497

ANALYSIS OF VARIANCEC

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CLASS	17.114	1	17.114	4.473	0.039
PERC1	150.782	1	150.782	39.406	0.000
CLASS* PERC1	6.806	1	6.806	1.779	0.188
ERROR	191.319	50	3.826		

TABLE 21

ANALYSIS OF COVARIANCE TABLE-PERCENT
COMPARING METHOD I WITH METHOD II

DEP VAR: PERC2 N: 54 MULTIPLE R: .692 MULTIPLE R2: .479

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CLASS	17.286	1	17.286	4.450	0.040*
PERC1	172.912	1	172.912	44.510	0.000
ERROR	198.125	51	3.885		

*Significant difference at the .05 level.

TABLE 22

ANALYSIS OF INTERACTION BETWEEN
TREATMENT (CLASS) AND
COVARIATE (TOT1)

DEP VAR: TOT2 N: 54 MULTIPLE R: .840 MULTIPLE R2: .706

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CLASS	1.934	1	1.934	0.233	0.632
TOT1	976.579	1	976.579	117.467	0.000
CLASS* TOT1	6.723	1	6.723	0.809	0.373
ERROR	415.684	50	8.314		

TABLE 23

ANALYSIS OF COVARIANCE TABLE-TOTAL
COMPARING METHOD I WITH METHOD II

DEP VAR: TOT2 N: 54 MULTIPLE R: .837 MULTIPLE R2: .701

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
CLASS	19.517	1	19.517	2.356	0.131
TOT1	987.667	1	987.667	119.248	0.000
ERROR	422.407	51	8.282		

percent subscore can be rejected. The squared multiple R of the percent analysis was .479. This shows a high main effect for percent.

Summary

There were significant differences between the compared means on the first hypothesis. The analysis indicated that taking a mathematics methods course significantly increases computation scores in nonnegative rational numbers among preschool elementary teachers. However, the strength of association showed a moderate to low effect size. Method I produced significant differences in pretest and posttest scores on decimals and total score with a moderate and a low effect size, respectively. Method II produced significant differences on decimals, percents, and the total score. The effect sizes for decimals and total were low and the effect size for percents was moderate. The analysis comparing the posttests of the two methods while holding the pretest constant showed that there were no significant differences between the groups with respect to fractions, decimals, or the total score. There was, however, a significant difference on percents. The class using Method II posted the greater gain. The strength of association showed the effect size to be large.

The means of the class using Method I were higher on all pretests. However, t-test calculations showed no significant differences in pretest scores between classes. Method II had a higher posttest mean score on percents.

CHAPTER V

SUMMARY AND CONCLUSIONS

This chapter presents a summary of the study, limitations of the study, conclusions drawn from the analysis of the data, the educational implications and recommendations for further research.

Summary

The purpose of this study was to determine if mathematics methods courses can improve computation in nonnegative rational numbers among preservice elementary teachers. Two different techniques of teaching were used. The study further attempted to determine if one of the methods was more effective in improving computation skills than the other.

This research was designed to investigate the relative effect of two methods of instruction on computation scores of nonnegative rational numbers of preservice elementary teachers. Method I was textbook based and used a lecture/demonstration technique of instruction. Symbolic, pictoral, and concrete examples were given at random, but all three modes were not given for any one concept. Mathematical competence was assumed. The emphasis was on pedagogy.

Method II was based on Jerome Bruner's three modes of representation, enactive (concrete), iconic (pictoral), and symbolic. The author developed a curriculum that followed Bruner's theory of instruction. Manipulatives were also constructed. Students experienced the three modes of representation as they progressed through the curriculum and used the manipulatives. Mathematical competence was not assumed, but was a goal. The textbook material was also presented.

Pretests and posttests were given to all students. The subtests were fractions, decimals, and percents. The total scores were also calculated. The statistical analyses consisted of analysis of variance, analysis of covariance, Pearson r, and tests for association.

Limitations

This study was conducted in the 1988 spring semester in two sections of Teaching Mathematics at the Intermediate Level. First, generalizations must be restricted to the hypothetical population determined by the sample. Second, the assignments were limited by time constraints. The study had to be completed within the time allotted for the topic.

Another limitation was the classroom situation. All assignments from the developed curriculum assigned to students in M_2 had to be completed outside of class. There was no assurance that each student used the manipulatives along with the booklet. Also, there was no assurance that each student did his or her own work.

Finally, the booklet used one set of manipulatives. There are many manipulatives that embody the same concepts. Possibly, the concrete, pictoral, and symbolic examples associated with the textbook material could produce similar results.

Conclusions

From the analysis of the data, the following conclusions were made congruent to the four questions posed in Chapter 3:

1. Completing coursework in an elementary mathematics methods course significantly increased the computation scores of preservice elementary teachers with nonnegative rational numbers. The effect size was moderate to low as defined in Chapter IV (Cohen and Cohen, 1983).

2. The lecture/demonstration method of instruction in an elementary mathematics methods course which assumes computational competence significantly increased the computation scores of preservice elementary teachers on decimals with a low effect size.

3. A technique of teaching in an elementary mathematics methods course which included Jerome Bruner's three modes of representation (enactive, iconic, and symbolic) and has math competency as a goal, increased the

computational scores of preservice teachers on decimals and percents with a low and moderate effect size.

4. When comparing the two methods of instruction (M_1 and M_2 as described in Chapter 2) in two elementary mathematics methods courses there was no significant difference on fractions, decimals, or total score. There was a significant difference in favor of M_2 on percents. The strength of association showed a moderate to large effect size.

Educational Implications

This study reports that many preservice teachers lack computational competence in certain computational skill areas. The computational skills addressed were in the area of nonnegative rational numbers.

The results indicate that completing coursework in an elementary mathematics methods course can improve mathematics computational skills with nonnegative rational numbers. The mean score for the total test for Method I increased from 21.963 to 23.815 and for Method II it increased from 19.815 to 23.333.

Assignments using Bruner's three modes of representation can improve computational skills. Although this method was significantly better than the lecture/demonstration method for percents, it requires additional time and expense. The total mean score on a scale of 30 for M_1 increased 1.852 points and for M_2 it increased 3.518 points.

Recommendations for Futher Research

The author suggests the following areas for further research related to this report:

1. Research on the effectiveness of computerization of Method II should be carried out. The booklet "A Teachers Kit for Rational Numbers" could be translated into a computer simulation. Students could be required to complete the assignments using personal passwords. In this way it is more likely students will complete their own work. This would also eliminate daily grading of each student's papers. In addition, the program could offer immediate feedback for correct and incorrect answers.

2. Further research should address the effectiveness of mathematics courses preservice elementary teachers complete as part of the required coursework. Perhaps courses specifically designed for the needs of elementary teachers as recommended by the NCTM and MAA could be implemented.

3. Studies on other ways to improve the computational skills of preservice elementary teachers are recommended. Remediation, math anxiety, or mastery learning might be addressed.

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APPENDIX A

CURRICULUM MATERIALS

Making Sets of Equivalent Fractions

Objectives:

1. Name fractional parts of a whole.
2. Give a written definition of equivalent fractions.
3. Write sets of equivalent fractions.

Activities:

1. Using the fraction circles, cover the white circle completely with each different color.

a. Fill in the chart.

	Draw the fraction	How many pieces?	What part is each piece?	What Fraction is equivalent to one?
Y				
DB				
O				
P				
LB				
B				

b. Write the set of fractions you made that is equivalent to one.

c. What do you see about all of the fractions that are equivalent to one?

d. State a general rule for writing fractions equivalent to one.

e. Write other fractions equivalent to one using your rule.

2. Use the fraction circle pieces to find fractions equivalent to 1/2. (Cover the fraction piece which represents 1/2 exactly with another color.)

a. Draw a picture of each one you find and label it.

b. Write the set of fractions you made that are equivalent to 1/2.

c. What do you see about the fractions in this set?

d. Write a general rule for finding fractions equivalent to 1/2.

e. Using your general rule, write other fractions equivalent to 1/2.

3. Think of two fractions that are equivalent.
a. How do the total amounts compare? (Same or different)

b. How do the number of pieces compare? (Same or different)

4. Use your answers in 3a and 3b to write a definition of equivalent fractions.

5. One times a number is that number. (One is the identity element of multiplication.)

a. 4 x 1 = 4 so 1/2 x 1 =

b. Multiply 1/2 by the each of the fractions you found that are equivalent to one. (See exercises 1b and 1e.)

c. How do the your answers in 5b compare to the set of fractions you found in 2b and 2e?

d. Using your answers to 5a,5b and 5c, state a general rule for finding sets of equivalent fractions symbolically.

EQUIVALENT FRACTIONS

Objectives:

1. Changing fractions to lower or higher terms.
2. Reducing fractions to lowest terms.
3. Recognizing fractions greater than one.

Activities:

1. A fraction made with fraction circle pieces can be traded for another fraction made with the circles if they are equivalent. (Cover the same space.)

a. Find the fraction circle piece representing 1/2. Trade it for an equivalent fraction by covering it exactly with another color. Draw and label the fraction 1/2 and the one you traded for.

b. Make 2/3 with the fraction circle pieces. Trade for an equivalent fraction by covering it exactly with another color. Draw and label the fraction 2/3 and the one you traded for.

C. When trading for an equivalent fraction, does the value change? Explain your answer.

2. Represent 2/6 with the fraction circle pieces.

a. Trade it for an equivalent fraction made with more fraction circle pieces. Draw and label your answer. (This is an equivalent fraction in higher terms.)

b. Trade 2/6 for an equivalent fraction made with fewer fraction circle pieces. Draw and label your answer. (This is an equivalent fraction in lower terms.)

c. Make 9/12 with the fraction circle pieces. Trade for an equivalent fraction made with the fewest possible pieces. Draw and label your answer. (This is an equivalent fraction in lowest terms.)

d. Use activities 2a, 2b, and 2c to write a definition of:

higher terms:

lower terms:

lowest terms:

3. Select four of the fraction circles that represent 1/3.
a. Draw and label the fraction these pieces make. (This type of fraction is called an **improper** fraction.)

b. Make a whole circle with the 1/3s and trade it for the fraction circle piece representing 1. How many 1/3s are left?

c. Draw and label the fraction you have made. (This type of fraction is called a **mixed number**.

d. State a general rule for changing an improper fraction to a mixed number.

4. Using the fraction circle pieces, make the fraction 1 1/4.
a. Trade the whole number for 1/4s. Draw and label the fraction you have made.

b. Describe the trade you made.

c. State a general rule for changing a mixed number to an improper fraction.

Addition and Subtraction of Fractions

Objectives:

Add and subtract fractions with common denominators.
Change fractions to common denominators.
Add and subtract fractions with different denominators.
Subtract fractions involving regrouping.

Activities:

1. Addition means putting things together. To solve 1/4 + 3/4, put together the fraction circle pieces representing 1/4 and 3/4.

a. When you put them together what do you have?

b. Draw and label the fractions before and after you put them together.

c. 1/4 + 3/4 =

d. Look at the fractions you added and the answer. What did you do with the top numbers (**numerators**)? What happened to the bottom numbers (**denominators**)?

e. State a general rule for adding fractions with the same bottom number (**common denominator**).

2. Subtraction means taking away or pulling down. To solve 3/6 - 2/6, put out the fraction circle pieces representing 3/6 and pull down 2/6.

a. When you pulled down 2/6, what was left?

b. Draw a picture of 3/6 and cross out 2/6.

c. 3/6 - 2/6 =

d. Look at the fractions you subtracted and the answer. What did you do to the numerators? What happened to the denominators?

e. State a general rule for subtracting fractions with the same denominator.

3. To solve 1/2 + 1/3, put out the fraction circles representing 1/2 and 1/3. When you put them together you cannot tell the answer. You must trade to get all the same color (common denominators) before putting them together.

a. What did you trade 1/2 for? What did you trade 1/3 for?

b. Draw and label your original problem and what you traded for.

c. Put the fractions together. Draw and label your answer.

d. Can you trade the answer for an equivalent fraction made with fewer pieces (lowest terms)?

e. 1/2 = /

+ 1/3 = /

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f. Describe in words how to add fractions with different denominators.

4. To solve 3/4 - 2/3, put out the fraction circle pieces representing 3/4. You cannot pull down 2/3 and you cannot change 3/4 to thirds. So, before you begin you must change both fractions to the same color.

a. What did you trade 3/4 for? What did you trade 2/3 for?

b. Draw and label what you put out and what you traded for. Cross out what you pulled down.

c. Can you trade the answer for an equivalent fraction with fewer pieces (lowest terms)? If so, what fraction?

d. 3/4 = /

- 2/3 = /

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e. Describe in words how to subtract fractions with different denominators.

5. To solve 1 1/3 - 2/3, put out the fraction circle pieces representing 1 1/3 and pull down 2/3.

a. Describe the trade you have to make in order to pull down 2/3.

b. Draw a picture of the problem before and after the trade and cross out 2/3.

c. 1 1/3 = /

- 2/3 = /

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d. State in words how to regroup when subtracting a fraction from a mixed number, when the bottom fraction is larger than the top fraction.

6. Solve these problems:

a. $\begin{array}{r} 6/8 \\ +\ 2/4 \\ \hline \end{array}$

b. $\begin{array}{r} 2/5 \\ 1/2 \\ +\ 5/10 \\ \hline \end{array}$

c. $\begin{array}{r} 2\ 2/3 \\ +\ 3\ 4/5 \\ \hline \end{array}$

d. $\begin{array}{r} 4/7 \\ -\ 2/7 \\ \hline \end{array}$

e. $\begin{array}{r} 3/5 \\ -\ 1/6 \\ \hline \end{array}$

d. $\begin{array}{r} 4\ 2/7 \\ -\ 2\ 2/3 \\ \hline \end{array}$

Multiplying and Dividing Fractions

Objectives:

Multiply and divide common fractions.
Multiply and divide mixed numbers.
State a general rule for multiplying fractions.
State in words the relationship between multiplipliplication and division of fractions.
State a general rule for dividing fractions.

Activities:

To multiply 3 x 4 means to take 3 4s. **** **** **** To multiply 1/2 x 4 means to take a half of four. So, you put out 4 and take half (pick up half). ** **

a. To solve 1/2 x 1/2, first put out the fraction circle pieces representing 1/2. Take (pick up) half of it. In order to do this, cover the 1/2 piece with another color which takes 2 pieces to exactly cover the 1/2. What 2 pieces exactly cover 1/2?

b. Pick up one of the pieces. What fraction circle piece do you have in hour hand?

c. Draw 1/2 and divide it into halves. What does one of the halves represent?

d. 1/2 x 1/2 =

e. Look at the two factors and your answer. What do you do to the numerator of the factors to get the numerator in the answer? What do you do to the denominators in the factors to get the denominator in the answer?

f. From 1e state a general rule for multiplying fractions.

2. Sometimes a multiplication problem begins with a mixed number. For example, in the problem 3/4 x 1 1/3, you take 3/4 <u>of</u> 1 1/3. Using the fraction circle pieces, make the mixed number 1 1/3. Now cover this fraction with 4 pieces all the same color so that they fit exactly.

a. What color did you cover it with?

b. Pick up 3 of the four parts (Because you want 3/4). What do you have in your hand?

c. Draw 1 1/3 and divide it into 4 equal parts. Circle three of the four parts.

d. Can you trade for a fraction made with fewer pieces (lowest terms)? If so, what is your final answer.

e. 3/4 x 1 1/3 = 3/4 x _____ = _______

f. Describe the extra step that you took when multiplying with a mixed number.

g. If you are multiplying a whole number by a fraction, what do you do to the whole number so you can use your general rule as stated in 1e?

h. Combine the answer in 2f and 2g with the answer in 1e to give a general rule for multiplying with mixed numbers.

3. When dividing the whole number 16 by 4, you ask "How many 4s are in 16?" When dividing one by 1/4, you ask "How many 1/4s are in one?"

a. Put out the fraction circle representing one and fill it with 1/4s. How many fit?

b. $1 \div 1/4 =$ ________

4. To solve $1/2 \div 1/4 =$ ____, first put out the fraction circle pieces representing 1/2 and cover it with 1/4s.

a. How many times does 1/4 fit?

b. $1/2 \div 1/4 =$ ________

c. Lets compare this problem with a similar multiplication problem.

$1/2 \times$ ____ $= 2$.

(How many times do you take (pick up) 1/2 to make 2?)

d. $1/2 \div 1/4 =$ ____

$1/2 \times$ ___ $= 2$

e. Use 4d to state the relationship between multiplication of fractions and division of fractions.

f. Does this always work? Experiment with other examples. Describe.

g. Using 4e and 4f, state the general rule for dividing fractions.

5. Solve these problems:

a. $1/4 \times 3/5 =$

b. $1\ 2/5 \times 8 =$

c. $4 \div 1/5 =$

d. $2\ 5/8 \div 3/4 =$

Making and Regrouping Decimals

Objectives:

Represent decimal fractions with place value squares and strips.

Regroup when there is more than nine in a place.

Regroup when more is needed in a place.

Activities:

The place value squares and strips can be used to represent numbers and to perform the basic operations on decimals and whole numbers. Each large square represents one, each strip represents one tenth, and each small square represents one hundredth.

1. Use the place value squares and strips to make the following numbers. Draw what you have made.

a. 2.63

b. Four and two tenths

c. .01

d. thirteen hundredths

2. Represent each picture with the place value squares and strips. Regroup by trading where possible. Draw and label your answer.

a. 

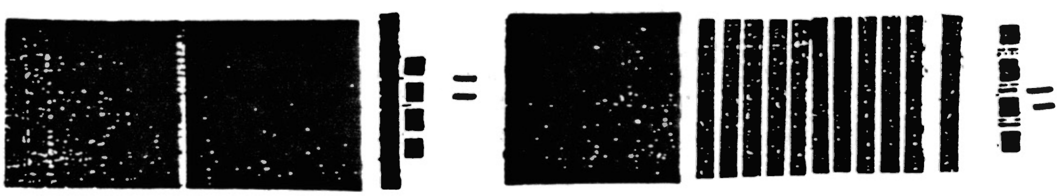
b. 

c. 

3. Represent each number with the place value squares and strips. Regroup by trading to make ten more in the place indicated. Draw and label your answer.

Example:

a. 2.14 tenths



2.14

b. 1.23 hundredths

c. 3.04 hundredths

Adding and Subtracting Decimals

Objectives:

Add and subtract decimal fractions.

State the relationship between adding and subtracting whole numbers and adding and subtracting decimal fractions.

Activities:

1. Represent .3 and .8 with the place value strips.

a. Add them by "putting them together". Draw the original problem and the answer.

b. Make a trade to regroup if possible. Draw what you did.

c.

$$\begin{array}{r} .3 \\ +\ .8 \\ \hline \end{array} \qquad\qquad \begin{array}{r} 3 \\ +\ 8 \\ \hline \end{array}$$

d. How is adding decimal fractions like adding whole numbers?

e. How are the decimals aligned in the problem?

f. How is the decimal point positioned in the answer?

2. Using the place value squares and strips represent these two numbers:

3 and 4 hundredths
2 and 3 tenths

a. Add them by "putting them together" Draw the original problem and your answer.

b. Write the problem and the answer with numbers.

c. Describe the alignment of the decimal points in the problem.

d. Describe the placement of the decimal point in the answer.

e. Give a general statement for adding decimal fractions. (Relate to adding whole numbers.)

3. Represent 4.26 using the place value squares and strips.

a. Subtract 2.13 by pulling down 3 from the hundredths place, 1 from the tenths place and 2 from the ones place. What number is left?

b. Draw the number you originally made. Cross out the number you subtracted (pulled down).

c.

$$\begin{array}{r} 4.26 \\ -\ 2.13 \\ \hline \end{array} \qquad \begin{array}{r} 426 \\ -\ 213 \\ \hline \end{array}$$

d. Describe the alignment of the decimal point in the problem.

e. Describe the placement of the decimal point in the answer.

f. How is subtracting decimal fractions like subtracting whole numbers?

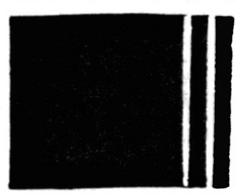
g. Give a general statement for subtracting decimal fractions. (Relate to subtracting whole numbers.)

4. Sometimes when subtracting decimal fractions with the place value squares and strips, there are not enough squares or strips in a place to pull down. In that case, trading (regrouping) must occur.

For example:

$$\begin{array}{r} 1.2 \\ -\ \ .9 \\ \hline \end{array}$$

Represent the top number with place value strips and squares



Nine strips cannot be pulled down from the tenths place. So the one square is traded for ten tenths. Now 9 tenths can be pulled down.

The answer is three tenths.

a. Represent 1.4 with the place value squares. Subtract .17 by pulling down. Trade (regroup) when necessary. Draw what you did. Cross out what you subtracted.

b. Write the problem and the answer in numbers.

c.

$$\begin{array}{r} 2.21 \\ -\ 1.83 \\ \hline \end{array} \qquad \begin{array}{r} 221 \\ -\ 183 \\ \hline \end{array}$$

d. How is subtracting decimal fractions with regrouping like subtracting whole numbers with regrouping?

5. Solve these problems:

a. 5.3 + 8.02 + 21.004 =

b.

$$\begin{array}{r} 5.708 \\ 21.08 \\ +\ 431.633 \\ \hline \end{array}$$

c.

$$\begin{array}{r} 26.78 \\ -\ 3.46 \\ \hline \end{array}$$

d.

$$\begin{array}{r} 53.1 \\ -\ 2.84 \\ \hline \end{array}$$

e. 42.003 - 41.006 =

Multiplying and Dividing Decimals

Objectives:

Multiply and divide decimal fractions.
State the relationship between multiplying and dividing whole numbers and multiplying and dividing decimal fractions.

Activities:

1. To multiply 2 x .13 using the place value squares and strips, represent 1 tenth two times and 3 hundredths two times.

2 x .13 = .26

a. Multiply 3 x 1.24 with the place value squares and strips. Regroup where necessary. Draw your answer.

b. Write the answer in numbers.

c.

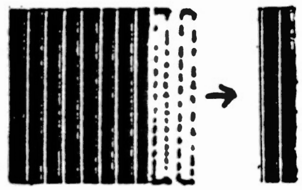
$$\begin{array}{r} 1.24 \\ \underline{\times \quad 3} \end{array} \qquad \begin{array}{r} 124 \\ \underline{\times \quad 3} \end{array}$$

d. Describe the alignment of numbers in the problems.

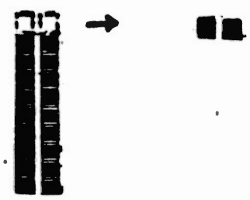
e. Describe the placement of the decimal in the answer.

f. How is multiplying by decimals like multiplying by whole numbers?

2. .2 times 1 means divide one into ten equal parts and take two.



.1 x .2 means divide two tenths each into ten equal parts and take one tenth of each.



a. Draw a picture to show what .1 x 2 means. Write the answer in numbers.

b. Draw a picture to show what .2 x .2 means. Write the answer in numbers.

c. Draw a picture to show what .01 x 3 means. Write the answer in numbers.

d. In 2a, how many places after the decimal point were in the two factors? How many places after the decimal point in the answer?

In 2b, how many places after the decimal point were in the two factors? How many places after the decimal point in the answer?

In 2c, how many places after the decimal point were in the two factors? How many places after the decimal point in the answer?

e. Using your answer in 1f and 2d, give a general statement for multiplying decimals.

3. Using the place value squares and strips, divide .1 by.01 by determining how many hundredths there are in one tenth. (Cover one tenth with hundredths.)

Ten hundredths cover one tenth.

$$\begin{array}{r} 10 \\ .01\overline{)\ .1} \end{array}$$

a. Divide .2 by .02 (Cover 2 strips with as many groups of 2 small squares as possible.) Draw two strips. Mark each with 10 equal parts. Circle as many groups of 2 as possible.

b. $.02\overline{)\ .2}$

$.02 \times 100 = 2$
$.2 \times 100 = 20$

$2\overline{)\ 20}$

c. How do the two answers in 3b compare with each other?

d. Does it change the answer of a division problem if both the dividend (number you're dividing into) and the divisor (number you're dividing by) are multiplied by the same power of ten?

e. $.04\overline{)1.3}$

Multliply the dividend and the divisor by 100 and solve.

$\overline{)}$

f. Use your answers on 3c-3e to write a general statement for dividing decimals.

4. Solve these problems:

a. $\begin{array}{r} 0.26 \\ \underline{\times\ 0.43} \end{array}$

b. $\begin{array}{r} 14 \\ \underline{\times\ 0.004} \end{array}$

c. $\begin{array}{r} 12.06 \\ \underline{\times\ \ 3.02} \end{array}$

d. $0.02\overline{)12.044}$

e. $1.02\overline{)6120}$

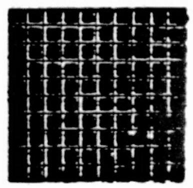
The Meaning of Percents

Objectives:

Make percents of one whole.
Write fractions and decimals as percents.

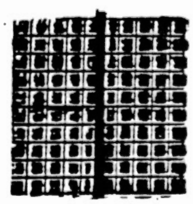
Activities:

Percent **means "part of one hundred"**. In any percent problem the whole is always divided into 100 pieces. Let's take the number one for example. Divide it into 100 pieces.



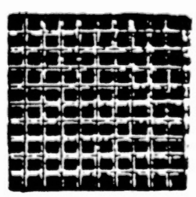
All of it is 100%. Each small square is 1%.

If we lay a straw down the middle we have divided it into halves. One half contains 50 small squares. It represents 50 percent.

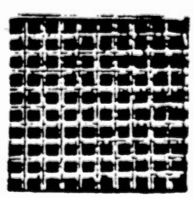


Use the square that has been divided into 100 pieces.

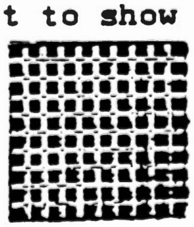
a. Lay the straws on it to show 25%. Draw you answer.



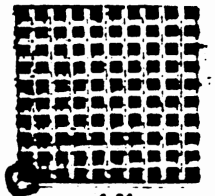
b. Lay the straw on it to show 10%. Draw your answer.



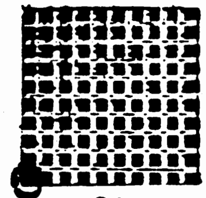
c. Lay the straw on it to show 75%. Draw your answer.



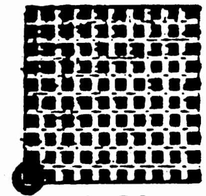
2. Percents can be written as fractions and decimals. When the number one is divided into 100 pieces, each small square is 1%. Each piece is also .01 and 1/100.



1%

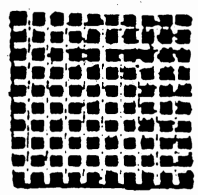


.01



1/100

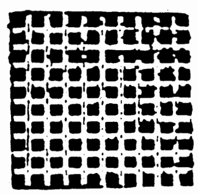
a. Place the straws on one square to show 50%. Draw your answer.



Now think of it as being a fraction. What fraction did you make?

Now think of it as being a decimal. What decimal did you make?

b. Show .60 by placing a straw on the square. Draw your answer.



What fraction did you make?

What percent did you make?

3. Sometimes a fraction or decimal is not written in hundredths. To change them to a percent they must first be written in hundredths.

a. 1/2 = ___/100 = ____%

b. .2 = .____ = ____%

c. 1/3 = ___/100 = ____%

d. 4 = __.___ = ____%

e. Use 3a and 3c to help you give a general rule for changing from fractions to percents.

f. Use 3b and 3d to help you give a general rule for changing decimals to percents.

g. State a general rule for changing percents to fractions.

h. State a general rule for changing percents to decimals.

4. Solve these problems:

a. $\frac{24}{100}$ = ______%

b. $\frac{9}{10}$ = _____%

c. 0.75 = ______%

d. 2.14 = _____%

Solving Percent Problems

Objectives:

Compute the percent when the part and whole are given.
Compute the part when the percent and whole are given.
Compute the whole when the percent and part are given.

Activities:

In percent problems there is a **percent**, a **whole**, and a **part**.

Percent problems can be written in this form:

<u>(percent)</u>% of <u>(whole)</u> = <u>(part)</u>

1. In the problem 40% of 80 = ? , the **part** is missing.

<u>(Remember percent means to divide the whole into 100 pieces)</u>

So each percent is equal to 80 divided by 100 or .80 In this case we want 40% or 40 pieces. 40 times .80 is 32, so 40% of 80 = 32.

Problem: 20% of 30 = ?

a. What is 1%?

b. How many 1%s do we want?

c. ____ x ____ =

Problem: 15% of 25 =

d. What is 1%?

e. How many 1%s do we want?

f. Solve and show your work.

2. In the problem ____% of 36 = 18 , the **percent** is missing.

We divide the whole into one hundred parts. 36 divided by 100 is equal to .36 If each percent is .36 and all of the percents times .36 equals 18, then to find the number of percents we determine how many .36s there are in 18. To do this we divide .36 into 18.

$$\begin{array}{r} 50. \\ .36\overline{)\,18.00} \end{array}$$

There are 50 1%s in 18. So, our answer is 50%.

Problem: _____% of 80 = 60

a. What is 1%?

b. How many 1%s are in 60?

c. Our answer is _____%

Problem: _____% of 14 = 28

d. What is 1%?

e. How many 1%s are in 28?

f. Our answer is _____%.

3. In the problem 60% of _____ = 9 , the **whole** is missing.

We know 60 of the 1%s are equal to 9. So, to find what the 1% is we divide 9 by 60.

$$\begin{array}{r} .15 \\ 60\overline{\smash{)}9.00} \end{array}$$

1% is equal to .15 so 100% is equal to 15.

Problem: 80% of _____ = 20

a. What is 1%?
(80 times some number is 20.
20 divided by 80 gives that number.)

b. What is 100%?

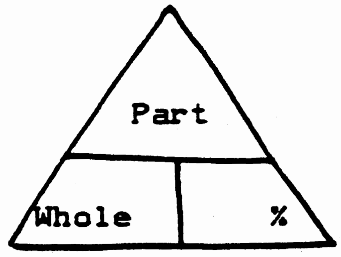
Problem: 75% of _____ = 30.

a. What is 1%?

b. What is 100%?

4. A convenient way to remember how to work percent problems is to think of this triangle.

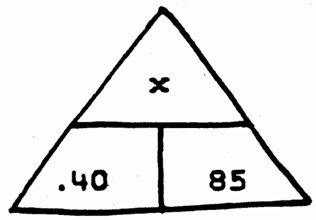
(Represent as 1%)



Fill in the known parts and solve for the missing number. (When one number is on top of another it means divide. When two numbers are side by side it means multiply.)

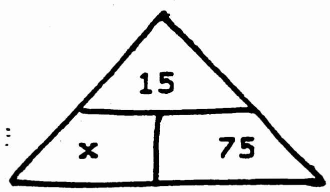
Examples: (Remember to change the whole to 1% by dividing by 100.)

85% of 40 = ?



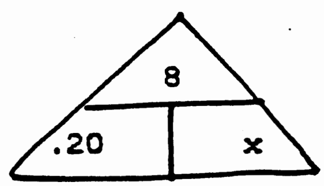
85 x .40 = 34

75% of ____ = 15



$\frac{15}{75} = .20 = 20$

____% of 20 = 8



$\frac{8}{.20} = 40\%$

5. Solve these problems.

a. 20% of 90 =

b. 300% of 12 =

c. ____% of 32 = 16

d. ____% of 19 = 36

e. 80% of ____ = 36

f. 150% of ____ = 90

APPENDIX B

SUMMARY TABLE

TABULAR SUMMARY OF RAW DATA

METHOD I

CASE	FRAC1	DEC1	PERC1	TOT1	FRAC2	DEC2	PERC2	TOT2
1	7	8	7	22	7	9	6	22
2	10	7	9	26	10	9	10	29
3	3	8	3	14	9	7	5	21
4	9	8	10	27	10	9	10	29
5	7	9	0	16	7	9	2	18
6	4	8	4	16	7	9	5	21
7	8	8	5	21	8	10	8	26
8	6	10	5	21	8	9	7	24
9	9	7	5	21	8	10	3	21
10	4	6	4	14	5	9	3	17
11	7	10	2	19	9	9	6	24
12	10	10	8	28	9	10	8	27
13	7	10	3	20	3	9	5	17
14	7	10	9	26	9	9	10	28
15	10	9	10	29	8	10	10	28
16	6	10	10	26	10	10	9	29
17	9	10	10	29	9	10	10	29
18	8	6	0	14	7	7	2	16
19	5	9	10	24	5	9	9	23
20	10	10	10	30	10	10	9	29
21	9	10	10	29	10	10	9	29
22	7	7	5	19	7	9	6	22
23	7	10	10	27	10	10	9	29
24	7	4	5	16	8	7	9	24
25	9	9	7	25	5	10	10	25
26	4	7	4	15	6	7	6	19
27	5	9	5	19	7	9	1	17

METHOD II

CASE	FRAC1	DEC1	PERC1	TOT1	FRAC2	DEC2	PERC2	TOT2
1	7	4	3	14	4	7	10	21
2	10	9	10	29	10	10	10	30
3	9	7	10	26	7	10	9	26
4	7	10	9	26	10	8	10	28
5	6	10	5	21	5	9	7	21
6	9	10	8	27	9	10	8	27
7	7	10	5	22	8	10	9	27
8	4	8	2	14	5	10	10	25
9	6	8	7	21	9	9	9	27
10	8	9	9	26	10	8	8	26
11	1	5	3	9	3	5	4	12
12	7	7	5	19	8	6	3	17
13	3	10	6	19	9	10	10	29
14	6	10	9	25	9	10	10	29
15	5	6	1	12	6	6	4	16
16	2	6	7	15	9	6	7	22
17	3	4	3	10	2	4	2	8
18	9	9	5	23	10	10	10	30
19	6	7	9	22	10	9	9	28
20	2	7	3	12	2	9	6	17
21	7	8	4	19	8	9	8	25
22	6	5	3	14	1	10	4	15
23	9	7	7	23	7	9	8	24
24	6	9	8	23	7	9	10	26
25	9	9	4	22	8	9	10	27
26	10	10	5	25	9	10	8	27
27	6	5	6	17	7	7	6	20

VITA ?

Ida Kay Wall

Candidate for the Degree of

Doctor of Education

Thesis: COMPARISON OF TWO METHODS OF PRESENTATION FOR NONNEGATIVE RATIONAL NUMBERS AMONG PRESERVICE ELEMENTARY TEACHERS

Major Field: Curriculum and Instruction

Biographical:

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Education: Graduated from Perry High School, Perry, Oklahoma, in May, 1961; received Bachelor of Science Degree in Education from Central State University in May, 1970; completed the requirements for the Master of Science in Education degree at Central State University in May, 1979.

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